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Meta-analysis: A Tool for Upgrading Inputs of Macroeconomic Policy Models

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Abstract

Meta-analysis is a research method to synthesise previously obtained research results. It is best seen as a statistical approach towards reviewing and summarising the literature. This paper aims to introduce and critically review the research method of meta-analysis and to illustrate its potential use in applied economic policy analysis. Special attention will be paid to the possibilities for value transfer and the possibilities to improve the calibration of existing macroeconomic policy models.

JEL codes: B40, C80

Key-words: meta-analysis, value transfer, research synthesis

1. Introduction

Meta-analysis is a research method to synthesise previously obtained research results. It is best seen as a statistical approach towards reviewing and summarising the literature (Stanley, 2001). The use of meta-analysis instead of, or in addition to, a literature review has some distinct potential advantages. One is, that meta-analysis is more 'objective' than the traditional literature review, although it is not necessarily free from subjectivity either. The other is, that meta-analysis constitutes a more systematic approach towards analysing the sources of (quantitative) variation in previously obtained research results.

The aim of this paper is to briefly introduce the research method of meta-analysis and to illustrate its potential by discussing some of the key contributions of the meta-analysis literature.[1] We also explore the potential of the so-called 'benefit transfer' or 'value transfer' technique, which is closely related to meta-analysis, and aims at 'predicting' research results for sites that so far have not been the subject of a primary analysis. Finally, we address the issue of the relevance of meta-analysis and value transfer for macroeconomic policy research. Can these techniques be used as a tool to improve the quality of the inputs used in macroeconomic models? More specifically, can meta-analysis be used to come up with better inputs for the calibration of general equilibrium models, and also, can value transfer be successfully applied to come up with estimates for sectors, time periods and institutional or geographical entities for which we are lacking credible information generated on the basis of research?

[1] For more extensive overviews of meta-analysis and its applications and potential in the field of applied micro- and macroeconomics, we refer to Button et al. (1999), and Stanley (2001), respectively. A general introduction to meta-analysis in Dutch is available in Kamp and Snijders (1997).

2. Meta-analysis: background

Glass (1976), one of the pioneers of meta-analysis, provides a widely accepted definition of meta-analysis. He states:

> "Meta-analysis refers to the statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings. It connotes a rigorous alternative to the casual, narrative discussions of research studies which typify our attempt to make sense of the rapidly expanding research literature."

Hunter and Schmidt (1990) very adequately and succinctly typify meta-analysis as the "analysis of analyses".

As a research method, meta-analysis has a longstanding and by now fairly strong position in psychology, education, the sciences, and medical research. Especially with respect to medicine, where (quasi-) experiments are common, and the urge and economic importance of what the 'bottom line' is regarding the effectiveness of a specific drug or treatment, this is of course easily imaginable. Meta-analysis provides the researcher with a tool to compare and/or combine outcomes of different experiments with similar set-ups (or, alternatively, differences in set-ups that can be controlled for). As such, it enables the researcher to draw more rigorous conclusions than would have been possible on the basis of either of the experiments considered in isolation.

Although each and every study may give a good indication of the sampling uncertainty of the effect that is being studied, meta-analysis opens up the possibility of investigating non-sampling issues such as research design, model specification and estimation technique, which are usually relatively constant within a study (Hedges, 1997). This is easily accomplished by including non-sampling characteristics as moderator or predictor variables in a (meta-) regression model. Another obvious advantage of a meta-

regression framework over the traditional literature review is the multivariate set-up that allows for the assessment of marginal effects, everything else remaining constant.

Given its quantitative orientation meta-analysis usually goes beyond what is called vote-counting (Light and Smith 1971). Vote-counting is often, more or less implicitly, used in literature reviews. It refers to simply counting and tallying significant results of a specific sign as well as zero-results. The inference that a specific category occurs in a majority of cases is usually taken as evidence for the size and direction of the 'true effect'. Vote-counting is, however, not very powerful in coming up with the right conclusion. It tends to result in a bias towards drawing the conclusion that the estimated relationship under consideration is statistically insignificant. It is especially prone to suggesting the wrong conclusion when the number of available studies increases (Hedges and Olkin 1980).[2]

Good monographs, edited volumes and 'textbooks' are now available describing the statistical methods to compare and combine research results (e.g., Hedges and Olkin 1985; Rosenthal 1991; and Cooper and Hedges 1994). Although most of these methods have been developed in an experimental setting, many of them can be also employed with quasi-experimental and non-experimental data.

3. Value or benefit transfer

It is not accidental that the early meta-analysis contributions in economics can be found in the area of environmental economics, and more specifically, in valuation research (Nelson 1980; Katzman 1987; Smith and Huang 1993, 1995; Schwartz 1994; Button 1995; Carson et al. 1996; Loomis and White 1996). The initially controversial technique of non-market valuation, using contingent valuation, travel cost methods, and hedonic pricing, obviously

[2] In a technical sense, this is due to Type-II errors of the individual studies that do not cancel out, but instead add up.

raised the question whether these techniques have sufficient validity and power to be useful in solving the valuation difficulties intrinsic to most environmental policy issues. Moreover, because most valuation methods (in particular contingent valuation) are based on extensive surveys and hence elicit information that is costly to acquire, one started speculating whether estimated values (or benefits) would actually be transferable. This area, concerned with the transfer of estimated values – or more general, effect sizes – was obviously prone to being combined with meta-analysis. Meta-analysis would provide a good summary indicator of what was available in the literature, and would hence be more effective as a 'prediction' for comparable sites that had not been studied in detail. The value transfer technique has been applied in the context of water quality, waste, and forest management, but especially the valuation of global ecosystem services and natural capital (Costanza et al. 1997) evoked a critical discussion among proponents and critics of the technique (Brouwer 2000).[3]

The application of value transfer is not necessarily linked to using values derived by means of a meta-analysis. Kirchhoff (2002) shows that value transfer on the basis of meta-analysis is not even necessarily better than transfers based on a single study result. It is only fair to note that to date, the experience with value transfer has not been very encouraging. Transfer errors as large as 56 – 475% have been observed (Brouwer 2000), and it is clear by now that instead of transferring 'values', one should actually transfer functions. The transfer of functions has the distinct advantage that differences in local conditions can be taken into account.

In sum, it is appealing and desirable from the perspective of cost-effectiveness to try and use meta-analysis to 'predict' the magnitude of effects or values of sites that have not been studied in detailed primary analyses. Our experience in doing so is, however, still limited, and as of yet not necessarily encouraging. However, until now value transfer has

[3] See the special issue of *Ecological Economics* (vol. 25, no. 1, 1998).

mainly been limited to the transfer of non-market values to different locations. The transfer of market-based valuations (such as elasticities) over time or over different sectors of the economy constitutes a largely unexplored terrain. We expect the potential of success of value transfer under such conditions to be much higher than in the traditional case of non-market value transfers over different locations (Dalhuisen et al. 2001).

4. Meta-analysis in practice

Doing a credible meta-analysis is not something that is done in a rainy Sunday afternoon. It is a rather meticulous and time-consuming task to create a good database, and develop a proper framework for the estimation of the direction and magnitude of effects. Obviously, it all starts with the selection of a topic suitable for a meta-analysis. This implies that the research results to be summarised should be available in a quantitative format, and they should – in principle – be comparable or fit to be made comparable. An ideal effect size measure is, for example, an elasticity revealing the responsiveness to price or income changes. It is obvious, however, that a sufficient amount of studies should have been published on the topic at stake.[4] Having selected a suitable topic and the studies addressing the direction and/or the size of the effect under consideration, the research papers have to be carefully codified. This should result in a database summarising the empirical knowledge about the topic under investigation. A typical database consists of:

- publication details of the study (such as, exact reference, year of publication, publication status, and the publication outlet);
- the estimate(s) of the effect size to be considered, and eventually information about its distribution (for instance, an estimated elasticity, and its associated standard error);

[4] It is a common misperception that meta-analysis constitutes a solution to limited information from primary studies. It is obvious, however, that this cannot be true, given the statistical nature of meta-analysis. Meta-analysis is not a panacea to what we cannot infer from primary research.

- estimation characteristics (such as, functional form, regression characteristics, number of observations, and the goodness of fit);
- 'background' variables (such as, type of data used, and geographical location and time period to which the study pertains).

Starting from such a database, the analysis can proceed in a variety of ways. Common elements of meta-analyses are simple descriptives of the effect size estimate (for instance, its mean, and standard deviation), and an analysis of variance representing differences in (conditional) means for studies with different background characteristics. Ultimately, one is however interested in the results of a meta-regression aiming at an explanation of the variation in either the sign or the magnitude of the effect sizes sampled from the literature.

Despite this basically simple and straightforward logic as well as structure of a meta-analysis, there are various specific problems that arise when trying to synthesise research results.

5. Common problems in meta-analysis

Unfortunately, the practice of doing a meta-analysis is not as straightforward as it may appear. A first – and admittedly rather obvious – problem, is concerned with attaining a representative sample of the literature. Modern bibliographical tools, such as EconLit and other (online) databases, and the easy availability of working papers through the Internet, do not prevail that it may be difficult to assess whether the sample of studies is in the end representative of the population of studies. Even more aggravating is the possibility that the studies that have been published constitute a biased sample of what has actually been found by researchers. Just imagine, that editors of journals have a tendency to reject 'negative' results (often associated with insignificant results; see McCloskey (1985) and McCloskey and Ziliak (1996) for a pervasive criticism of this practice). Research results found in the

literature are then necessarily biased towards significant 'positive' results, and a meta-analysis would thus be concerned with what might mistakenly be considered to represent the 'truth', but is much more likely a biased representation of what has been published. This of course stresses the relevance of gathering a representative sample of studies, including those studies that report 'negative' results. The latter can often be found in, for example, unpublished working papers or in unpublished manuscripts that researchers – either as a result of self-censoring or repeated rejection by journal editors – put away in the file drawer (Rosenthal 1979). Obviously, this type of studies is difficult to attain, and at the same time crucial for a good representation of the population of studies.

A second problem is concerned with the comparability of estimated effect sizes. This is not always straightforward. For instance, in Mulatu et al. (2002) the authors discuss at great length what had to be done in order to make estimates from the empirical literature on the relationship between international trade and stringency of environmental policy comparable. In the end, effect sizes derived from exploratory, Leontief-type, and econometric studies on this topic could only be compared in terms of their direction (negative or positive). But even in much more straightforward cases, problems may occur. A simple example can illustrate this point. Elasticities estimated using a double logarithmic specification are generally different from point elasticities evaluated at the sample mean of prices and quantities. There is no a priori preference for one or the other, and it is impossible to favour either of them on the basis of statistical or theoretical arguments. Alternatively, elasticities may be different in their time horizon (short vs. long-run elasticities), or even more complex, their base may be different (De Mooij and Ederveen 2001). In a strict sense, the elasticity estimates obtained by different methods, or referring to slightly different bases, are hence incomparable. This is not necessarily detrimental to performing a valid and thorough meta-analysis, but it requires careful consideration of how differences should be coded, and what the implications are for

the functional specification of the meta-regression. Oftentimes, differences such as those mentioned here, are taken into account by fixed or random effects. Evidently, this is exactly the stage where a certain element of subjectivity is unavoidable in meta-analysis as well. In the end, meta-analysis can therefore not circumvent the subjectivity that is present in the traditional literature review.[5]

A third problem is related to the formidable heterogeneity among studies. In medicine and the sciences replication is a common characteristic. In economics, on the contrary, it seems to be a common desideratum of research that the investigator be 'original' and 'innovative'. As a result, it is not straightforward to account for all this heterogeneity, and many meta-analysts rely on simple fixed or random effects to account for such differences. Two circumstances aggravate this problem even further. One is common to all research: how to account for quality differences among studies? In economic meta-analyses this is usually not addressed, except for the variation in precision of effect sizes due to differing sample sizes of the underlying studies.[6] The other is much more typical of economic research: in contradistinction to experimental sciences, economists are generally rather 'sloppy' in adequately reporting statistical results as well as providing sufficient information about the statistical characteristics of the sample observations. Although providing insufficient or incomplete information may not be all that relevant for the study as such, it is extremely relevant for the comparison of results among different studies, and it is of paramount importance for a proper and justifiable construction of a good database.

A final problem, common to meta-analyses in the experimental sciences as well as the non-experimental sciences, concerns the assumption of independence of the observations. In

[5] One should note, however, that the subjectivity in meta-analysis is usually much more 'visible', and the foregoing should have made clear that meta-analysis has a number of other distinct advantages over a literature review.

[6] In technical terms, this causes heteroscedasticity and may be remedied through weighting the observations or robust inference.

the (experimental) sciences this assumption can usually be defended because the tradition of doing replications makes that one estimate per study can be sampled, without running into degrees of freedom problems. In economics, however, the generally much more limited number of available studies, which as a rule provide various 'competing' specifications, necessitates the meta-analyst to sample more than one observation per study. As these observations are derived from the same data, the lack of independence is obvious. The potentially negative effects of this problem (e.g., biased estimates in the meta-analysis) are usually simply disregarded.

All of these problems are, however, increasingly recognised in the community working on meta-analysis. Fortunately, this results in the development of new, and more sophisticated techniques (e.g., multilevel techniques, and tests and estimators taking into account publication bias), to cope with the potentially negative effects of disregarding these problems inherent to meta-analysis. This is of course of paramount importance for the validity and the credibility – and in the end, as a result, the acceptance – of a relatively new technique, such as meta-analysis.[7]

6. Meta-analysis in economics

In the field of economics, meta-analysis was first introduced in environmental economics. Nelson (1980) is the first study, and merely provides an average Noise Depreciation Index over studies, in addition to a qualitative survey of property value studies estimating the impact of airport noise. The non-market valuation issue and its being fraught with methodological problems related to, for instance, properly defining the 'good' to be valued, protest non-response, differing elicitation formats and payment vehicles, and part-whole bias,

[7] A meta-analysis based on just 19 observations, with 5 degrees of freedom in the estimation, and a total ignorance regarding the use of fixed effects in regression (Rose 2001), does not only lead to senseless and useless results, but it also ridicules the potentially large benefits associated with meta-analysis.

evoked a whole series of meta-analyses. Florax (2002) shows that approximately 40 meta-analyses appeared between 1980 and 2001, half of them addressing the valuation of pollution and recreation, and one-third being concerned with the nexus of agriculture, land use, and natural resources. Some of the very innovative and methodologically interesting studies are linked to the efforts of Kerry Smith (Smith and Kaoru 1990a,b; Smith and Huang 1993, 1995; Smith and Osborne 1996). A series of much more straightforward studies, mainly on demand elasticities, is due to Molly Espey (1996, 1998; Espey and Kaufman 2000; Espey and Thilmany 2000; and Espey et al. 1997).

Although environmental economics has been leading the way, the concept of meta-analysis is now also being picked up in other areas in economics. There is work in labour economics (Card and Krueger 1995; Doucouliagos 1997, Ashenfelter et al. 1999; Groot and Maassen van den Brink 2000), and in industrial organisation (Jarrell and Stanley 1990; Button and Weyman-Jones 1992, 1994; Sinha 1994; Doucouliagos 1995; Fuller and Hester 1998). There are also studies in transportation economics (Button 1995; Button and Kerr 1996; Button and Rietveld 2000; Wardman 2001), and marketing constitutes an area where there is substantial use of meta-analysis (Peterson et al. 1985; Sheppard et al. 1988; Brown and Stayman 1992; Peterson 1994; Homburg and Baumgartner 1995; Verlegh and Steenkamp 1999). The area of general economics has for very long been disregarded, but the first studies are now appearing (Phillips and Goss 1995; Stanley 1998, 2001; Croson and Marks 2000). Some studies are even solely concerned with methodological issues of meta-analysis in economics (Vanhonacker et al. 1990; Vanhonacker and Price 1992; Neumark and Wascher 1998; Bijmolt and Pieters 2001).

One may speculate as to the reasons of why meta-analysis diffuses through economics in this particular way. Apart from personal preferences of researchers and mere chance, it seems like the lack of data and the formidable cost of acquiring data in environmental

economics has contributed to its role as forerunner. Macroeconomists, who generally have a considerably better access to a large pool of easily available data, may actually have preferred substituting a value transfer estimate derived by means of meta-analysis by a primary estimate (eventually even 'quick and dirty' if necessary). It is clear, however, that meta-analysis is now picking up throughout all areas in economics. In the next section we will centre on the potential of meta-analysis for model calibration in macroeconomics.

7. The potential of meta-analysis for model calibration in macroeconomics

Given the above-mentioned penetration of meta-analysis into various areas in economics it is surprising – to say the least – that meta-analysis has only occasionally been applied to macroeconomic issues. Especially, since there is an abundance of (primary) empirical studies, and summary statistics are often clearly defined and easy to identify. Moreover, there appear to be what one could call – but also question, of course – 'natural constants', such as the Non-Accelerating Inflationary Rate of Unemployment (NAIRU), 'Tinbergen's 2', and the 1.5-2% rate of convergence in growth literature. And finally, there is an obvious need for consensus estimates in both applied general equilibrium modelling and in policy oriented macroeconomic research. From a methodological point of view the application of meta-analysis is particularly promising, given the availability of a huge amount of studies with easily identifiable summary statistics. Even a rather superficial perusal of EconLit already reveals that there are approximately 6o potentially useful studies estimating Engel curves and related price and income elasticities of demand for different consumption categories, and approximately 45 usable studies considering the estimation of NAIRUs. It is easily possible to simply continue this list with numerous other examples.

Among the potential benefits related to the application of meta-analysis in the field of macroeconomics are a better calibration of policy models, and the incorporation of all

available empirical knowledge about a specific relationship under consideration. Meta-analysis may also contribute to an improved understanding of problems associated with particular estimation techniques, and provide a 'reliable' input for subsequent primary analyses. Finally, there is the possibility of using value transfer for regions or sectors for which data availability is a persistent problem (for instance, less developed regions or countries, and specific sectors, such as the service sector).

The application of meta-analysis in the field of applied macroeconomics poses several challenges as well. In order to ensure usefulness for applied general equilibrium modelling, a close collaboration between theorists and empirical researchers is desirable. Given the low costs of doing primary research in these fields, the 'natural scepticism' of many researchers against meta-analysis may be predominant – at least initially. An increase in the number of available meta-analyses in macroeconomics, which given the above-mentioned diffusion of meta-analysis in economics seems to be merely a matter of time, will most likely add to an increased understanding and familiarity with the methodology. Although meta-analysis is not straightforward and it necessitates the meticulous and time-consuming construction of databases, there is an indisputable pay-off in terms of obtaining improved 'consensus estimates' and detailed insights in the available empirical material.

8. Conclusion

Meta-analysis is increasingly seen as a useful research method to provide a quantitatively robust complement to the traditional literature review. Meta-analysis is less prone to 'subjectivity', and it can help explain the abundant variation in empirical estimates often encountered in empirical research. Apart from providing a quantitative survey of the literature, the combination of research results is likely to give rise to new insights as well. An area in economics that is still very much open to the application of meta-analysis is the area

of applied, policy-related, macroeconomics. For now, it seems that the relatively easy – and hence almost costless – availability of data still provides a major incentive to relying on additional primary research. We have emphasised, however, that there are major gains to be accrued from applying the relatively new technique of meta-analysis. Meta-analysis is crucial in providing a systematic, and statistically rigorous, overview of the plethora of studies usually available to the researcher, and it can help in improving future primary research. The calibration of macroeconomic models, relying heavily on inputs of empirically estimated elasticities, can gain much from a systematic review and a precise quantitative assessment of key parameters.

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